NASA TT F-12,212

NEW VICTORY IN SPACE RESEARCH

G. I. Petrov

Translation of: "Novaya Pobeda v Issledovanii Kosmosa"
Vestnik Akademii Nauk S.S.S.R., No. 11,
November, 1968, pp. 4-6.

N69-25185

FACILITY FORM 602

(ACCESSION NUMBER) 5 (THRU) 1

(PAGES) (CODE)

(NASA CR OR TMX OR AD NUMBER) 2 31 (CATEGORY)

MAY 1969

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 APRIL 1969

NEW VICTORY IN SPACE RESEARCH

Academician G.I. Petrov

ABSTRACT: The author discusses the complex problems encountered in planning a safe entry and, in particular, a precise landing of a spacecraft coming from orbit around the Moon or some other planet of the solar system. He shows how these problems were solved successfully in the flight of "Zond 5".

Soviet science and technology have won a new outstanding victory in space research. For the first time history, the automatic station "Zond-5", having flown around the Moon, has returned to Earth. /4*

Automatic apparatus of various types launched in the Soviet Union are plowing through the oceans of the universe, carrying out various types of scientific investigations. Satellites of the "Kosmos" series are making studies in the space around the Earth on a large-scale scientific program. Automatic stations of the series "Zond", "Luna", "Mars" and "Venera" are being used in order to investigate the space around the Moon and interplanetary space. In studying the Moon with the aid of the automatic apparatus from the "Luna-1" station (1959) to the "Zond-5" station, the Soviet creators of space technology - scientists, engineers, workers - have solved such basic priority problems as the first photographing of the reverse side of our eternal satellite with the transmission of photographs to the Earth, the first soft landing on mysterious Selene, the flight of its artificial satellites in the space around the Moon, and, finally, the reliable plotting of the first interplanetary course Earth-Moon-Earth.

Scientific information on the physical processes which take place on the Moon and the space around it had been obtained in large volume. However, none of the previously-launched automatic apparatus had as yet returned to the Earth. The problem itself had not been raised at that time. Scientific information was transmitted from the apparatus by radiotelemetric channels. However, not all the information obtained by scientific apparatus can be analyzed on board the spacecraft. Thus, the results of the effect of high-energy rays on the matter and scientific instruments in space can be investigated and evaluated more profoundly and effectively only on the Earth. Therefore, the problem of acquiring

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* Numbers in the margin indicate pagination in the foreign text.

information from space directly in the scientific laboratories was put on the agenda. This problem was solved brilliantly by the Soviet automatic station "Zond-5". As is well known, it was launched on September 15 at 0042, Moscow Time.

The "Zond-5" station with the final carrier-rocket stage was originally put into the orbit of an artificial Earth satellite. About one hour after take-off, the last carrier-rocket stage was engaged, which gave the station an additional increase in speed on the order of 3.5 km/sec. The total flight speed of the station was thereby increased roughly up to 11,000 m/sec. When the engine system stopped operating, the carrier rocket was separated. After the station went on the flight route toward the Moon, the necessary trajectory measurements were carried out. An analysis of these measurements showed that the trajectory for the motion of the station was close to that which was calculated. The parametric information confirmed the normal functioning of all on-board systems and scientific apparatus.

In order to guarantee flight around the Moon at a specified distance from it, corrections of the trajectory for motion of the station were made. At this time, the station was about 60,000 km from the Moon.

How was the correction made? For the beginning, the station was oriented in space. For this purpose, it acquired a certain angular velocity for finding and capturing the Sun with the aid of the optical pick-up, and then turned, in order to find the Earth and capture it with the aid of the corresponding pick-up. After this, the programmed turn of the station to its original position was carried out with the on-board system of autonomous control for the purpose of correction. The engine system which transmitted the correcting impulse of requisite magnitude to the station was then turned on. As a result of the maneuvers carried out, the station went into a new flight trajectory in order to carry out investigations of the physical characteristics of the space in the region of the Moon. /5

On September 18, the stat-on flew around the Moon at a distance of 1950 km from its surface.

After the flight around the Moon, the station continued to move along the flight course, coming closer to the Earth. During this flight segment, the necessary trajectory measurements and scientific studies were carried out. As is well known, one of the principal tasks for the flight of the station was to guarantee its return to the Earth and its landing in a specified region.

Among the many problems connected with interplanetary flights, one relates to that relatively short flight period when the space apparatus, returning from "long travels", enters the atmosphere of

our own planet. We have already learned how to return spacecraft in orbit in the space around the Earth reliably to the Earth. The descent and landing of spacecraft returning to the Earth from an interplanetary flight is a problem which is many times more complicated than return from orbit of an artificial Earth satellite. Obviously, it would not be an exaggeration to say that the entry into the Earth's atmosphere and landing of such apparatus on its surface is one of the most complicated problems now raised before astronautics. What is the reason for this? The complexity of a landing is due to the fact that, in the entry of a space station into the Earth's atmosphere at second cosmic velocity (more than 11 km/sec) it is subjected to more inte ive aerodynamic heating than is an Earth satellite, which has a velocity of about 8 km/sec. This not surprising. In fact, the aerodynamic heating of flying bodies is proportional to their velocity raised to the third power.

However, the air drag and, consequently, the aerodynamic heating caused by it depend not only on the flight speed of the space station but also on the angle at which it enters the atmosphere. The body undergoes greatest heating in a vertical entry. Meteor bodies which fly along such trajectories and burn in the atmosphere undergo this.

On the other hand, the angle of entry of the apparatus into the Earth's atmosphere should not be too small. In a mildly sloping entry, the drag of rarefied layers of the air can be so insignificant that the apparatus cannot cancel its great speed. It flies through these layers without slowing down and again goes into air-less space. Only the attractive forces of the Earth hold it somewhere. Having described an ellipse by the effect of the forces of gravitation, the apparatus again returns into the Earth's atmosphere. Only after passing through the upper layers of the atmosphere many times is it able to cancel its speed and guarantee a safe descent and landing on the Earth. However, this "cosmic merry-go-round" has nothing to its advantage. It not only increases the time for the apparatus to exist in space around the Earth, but also affects the accuracy of its incidence in a specified region to a great extent.

Where is the "golden mean" between these two extreme conditions? There are not that many intermediary trajectories. They are all within a very narrow "corridor" for a safe entry into the Earth's atmosphere. This corridor is limited, on the one hand, by the danger of flight past the Earth, and, on the other hand, by the value assumed for permissible G-load. It has been established that in a ballistic descent G-loads of 10-12 units are guaranteed in entry into the atmosphere at an angle of inclination of the trajectory toward the local horizon on the order of 5-6°. An increase in the angle of entry by 1°, for example, results in an increase of G-loads up to 30-40 units. /6

A decrease in the angle of entry by this value can result in

a situation where the spacecraft is not "captured" by the atmosphere, i.e., it flies past the Earth. Calculations show that, if an apparatus enters the atmosphere at an angle no less than 5-6° and no more than 7-9°, then the width of the corridor does not exceed 10-13 km in this case for a G-load of 10 units.

It is completely understandable how perfected the apparatus for automatic nagivation of the spacecraft must be in order that it may enter this corridor from the interplanetary course and move precisely along it. Therefore, in order to guarantee a reliable return of a space station in the vicinity of the Moon, it was necessary to solve many completely new and very complicated scientific and technological problems.

As the flight of the automatic station "Zond-5" showed, these problems were solved in full.

All the systems of the station functioned normally. The flight in the atmosphere went along the ballistic trajectory with calculated G-loads, and the approach of the descending apparatus took place at a previously designated site on the Indian Ocean.

The program of the Soviet automatic station "Zond-5", which was the first in the world to complete a successful flight around the Moon and return to the Earth, has been accomplished in full. Wide prospects for studying outer space, the Moon and the planets of the solar system with automatic space apparatus are henceforth open.

**Translated for the National Aeronautics and Space Administration by:
Aztec School of Languages, Inc.
Research Translation Division (341)
Maynard, Massachusetts.
NASw-1692.**